The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

DECEMBER, 1889.

Thou, Lord, in the beginning hast laid the foundation of the earth, and the heavens are the works of thine hands.

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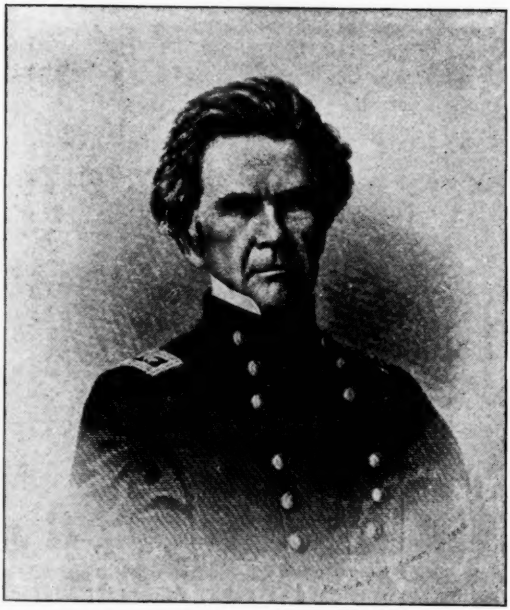

O. M. MITCHEL.

THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE RESISTING MEDIUM IN SPACE.

ASAPH HALL.*

For THE MESSENGER.

To any one who looks at our solar system in a simple way, and who observes the continual communication of light and heat from the sun to the planets, and the steady action of the gravitating force which bends the courses of the planets into ellipses round the central body, it would be natural, perhaps, to assume that there must be some material medium in the planetary spaces, by means of which these forces act through the great distances that separate the sun from his attendant planets. Such a medium may resist the motion of a planet through it, and as it would act unceasingly, its effect would be cumulative, and hence would arise an important question, necessary to be examined in the theory of celestial mechanics. In fact the early investigators soon gave their attention to this question, and more than a century ago the Abbe Bossut sought in the effect of a resisting medium an explanation of the secular acceleration of the moon's motion. An analytical investigation of the action of such a medium on the motion of a planet is given by Cousin in his Physical Astronomy, published in Paris, 1787; and afterwards La Place investigated this question in the *Mecanique Celeste,* Tome IV. A more complete examination of the theory of perturbations, however, showed that the law of gravitation alone was sufficient at that time to explain the motions of all the heavenly bodies.

The results for a resisting medium depend, of course, on the law assumed for the resistance. With the laws of resistance as they are known from observation on the earth the general effects on the motion of a planet are as follows:

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(1). *The position of the plane of the orbit is not changed.*

(2). *The mean longitude of the planet and the longitude of the perihelion undergo only periodical changes.*

(3). *The mean distance of the planet and the excentricity of its orbit are continually diminished.*

The first result seems almost self-evident; but the important changes are those of the third kind. From these it follows that the motion of the planet is constantly accelerated and at the same time the orbit continually approaches a circular form. The final result therefore under these conditions is that the planet falls into the central body.

As simple a way perhaps as any of reaching these results by analysis is that given by Poisson in his *Mecanique*. The method employed is that of the variation of the four constants that belong to the plane of the ellipse described by the planet. However the formulæ take a somewhat neater form by using the excentric anomaly as the independent variable instead of the true anomaly as Poisson does. The law of density of the resisting medium generally assumed is that it varies inversely as the square of the radius vector of the body. There is an uncertainty in this assumption which it is difficult to avoid, since many laws may be assumed that will give nearly the same results. Having assumed the law of density the principal parts of the integrals can be obtained at once when the excentricity of the orbit is small, but when the excentricity is great, as in the orbits of comets, the perturbations can be expressed by means of elliptic integrals. The differential equations for the mean distance and the mean motion of the body can be written in a simple form, and so that they exhibit very plainly the resulting effect of the resisting medium on these elements. If a is the mean distance, μ the mean motion, and c the velocity of the body in the unit of time; r its radius vector, and U the disturbing force acting in the direction of the tangent, these equations are:

$$\frac{da}{dt} = \frac{2a - r}{r} \cdot \frac{2a}{c} \times U$$

$$\frac{d\mu}{dt} = -\frac{3(2a - r)}{r} \cdot \frac{\mu}{c} \times U$$

In these equations $2a-r$ is the distance of the body from the vacant focus of the ellipse, and all the factors that multiply U are positive in every part of the orbit. The integral effect, therefore, on a and μ will depend on the character of the disturbing force. In the case of a resisting medium U will be negative, so that the mean distance will be diminished, and the mean motion will be increased.

The plausibility of the existence of a resisting medium in the planetary spaces has been increased by the adoption of the wave theory of light, which assumes a luminiferous ether pervading the universe. The character of this ether has been described in various ways; generally, however, as a vast solid body, through which the dense planets move without hindrance but which may present some resistance to the motions of comets. Hence it is from the motions of these light and expanded bodies that we should expect to learn something about a resisting medium in space. But whatever may be the physical theories of light, and the theoretical qualities of the luminiferous ether, let us see what the observations of comets have shown.

The most famous of the periodical comets whose motions have been carefully investigated is the Encke comet, discovered by Mechain in 1786, and again by Pons in 1818, when its short period of about 1212 days was first detected. For a long time Encke persisted in calling it the Pons comet, but his own laborious investigations on the motion of this comet have justly given it the name of the *Encke Comet*. On account of the short period of this comet and its near approach to some of the planets, the work of computing the perturbations is very great. The persevering labor of Encke through so many years deserves the highest praise. Beginning with the earliest observations he reduced many of them anew, computed the perturbations produced by the six principal interior planets, formed normal places and equations of condition, and deduced the best elements of the orbit; also a correction to the mass of Mercury and the coefficient depending on the resisting medium. The work of Encke extends from 1786 to 1858, and altogether it is one of the most laborious computations ever performed by an astronomer. This comet passes inside the orbit of Mercury and in some cases approaches so near the planet that it is

necessary to compute the coefficients of the perturbations for every second day. Under the assumption of a resisting medium, and because the observations are all made near perihelion, the mean motion of the comet will have the form,

$$\mu' = \mu + 2\alpha\,(t - T)$$

where μ is the pure elliptic mean motion, T the epoch, and α a constant coefficient to be found from observation.

The mean anomaly will be:

$$M = \mu\,(t - T) + \alpha\,(t - T)^2$$

The expression for the excentricity of the orbit will be:

$$e' = e - \beta\,(t - T)$$

In the case of the Encke comet the coefficient β is very small, and it may be neglected for several revolutions of the comet. Taking the epoch

$$T = 1829, \text{Jan. } 9.72 \text{ Paris M. T.}$$

the periodic time resulting from Encke's computations, extending over 72 years, is

$$1211^{d}.3259 - 0^{d}.117573\ .\ r$$

where r denotes a revolution of the comet. Each revolution, therefore, since the epoch is diminished by $2h\ 49.3m$; so that from 1818 until 1885 the periodic time would be shortened 2⅓ days. A careful examination of Encke's methods and work will convince anyone, I think, of the truth of his result that the period of this comet was diminishing by nearly this amount during the time 1786 to 1858.

After the death of Encke in 1865 the computations on this comet were undertaken by Dr. Von Asten and Dr. Becker, and after a short time the entire work passed into the hands of Dr. Von Asten. These calculations were pursued with great zeal and industry by him until his death in 1878. Von Asten recomputed the perturbations and made a complete investigation of the motion of the comet from 1819 to 1875. As a general result there was found to be a good agreement with the theory of Encke in respect to the resisting medium But an exception occurs for the interval from 1865 to 1871, when it was found that no resisting medium was required to satisfy the observations. This investigation is very elaborate, Von Asten's equations of condition containing eleven unknown quantities; the six elements of the orbit of the comet, the coefficient for the resisting medium, and corrections to the masses of Mercury, Venus, Earth and Jupiter.

After the death of Von Asten the computations on the Encke comet were undertaken by Mr. O. Backlund of the Pulkowa Observatory, now professor in St. Petersburg, in whose able hands they remain. Backlund found on revision that the result reached by Von Asten for the years 1865 to 1871, of the non-existence of a resisting medium, came from a small error in computing the perturbations during that time. He has deduced elements of the orbit of the comet from the observations made in the years 1865 to 1885, and his representation of the normal positions for these years is excellent. The corrections to the masses of the planets have been omitted in Backlund's discussion, except for Mercury. The final result is that the coefficient of the resisting medium has only one-half the value found by Encke and Von Asten from the earlier observations of the comet. The mass of Mercury comes out very great, but agreeing nearly with the value found by Encke from all the appearances of the comet from 1818 to 1848, and curiously enough, with the old value assumed by Lagrange from rather arbitrary analogies. In fact, a singular feature in the investigations of the motion of this comet is the variation in the resulting mass of Mercury. These values of the mass are as follows, the mass of the sun being the unit:

MASS.	OBSERVATIONS.	COMPUTER.
1 : 3271742	1818 to 1848.	Encke.
1 : 10252900	1828 to 1848.	Encke.
1 : 8234192	1828 to 1848.	Encke.*
1 : 7636440	1818 to 1868.	Von Asten.
1 : 2668700	1871 to 1885.	Backlund.

A decided change in the effect of the resisting medium appears to be clearly shown by the observations, so that after 1870 the coefficient is reduced to one-half the value found before that time.

Soon after Encke proposed his theory of a resisting medium in space the objection was brought forward that this theory is too general, since the motions of the planets and of other comets are not affected by such a medium. However a short time before his death Encke had the satisfaction of seeing the work of Professor Axel Möller on Faye's comet, which showed that a resisting medium was also necessary to account for the motion of this comet. Since the Encke

* Rejecting observations after passage of perihelion.

and Faye comets move in very different parts of the planetary spaces, the Faye comet having a period of seven and one-half years, this result was a striking confirmation of the existence of such a medium. But in later computations Professor Möller has removed this apparent confirmation, since he has found that the whole series of observations can be represented very well by means of the law of gravitation alone, so that there is no need of a resisting medium. The first and erroneous result appears to have been produced by the method of computing the perturbations in rectangular coördinates, which give the perturbations in such a form that one does not easily see how the elements are changed. This method was devised by Bond and Encke, and it is theoretically very simple, but though strongly recommended by Encke it does not work so well in practice as the old method of the variation of the elements.

Dr. E. von Haerdtl has recently published a very elaborate investigation of the orbit of the Winnecke comet, whose motion also was at first thought to be accelerated, and finds, after a complete discussion of the observations, no evidence of a resisting medium. This work is very complete, and the calculations appear to have been made with the utmost care. The situation of this comet is intermediate between those of the Encke and Faye comets. Its period is about five and one-half years, and the work of Dr. von Haerdtl extends from 1858 to 1886.

At the present time, therefore, the general result of all the investigations on the motions of comets is that the Encke comet alone shows evidence of a resisting medium; and in this case the coefficient of resistance has been diminished one-half for the observations made during the last five appearances, or from 1871 to 1885. Such a result must lead to the examination of what is peculiar about this comet, and its position in space. The perihelion distance is so small that the comet can approach very near to Mercury, within 0.04, and the discordant values of the mass of this planet found from the discussion of different series of observations have been referred to; but all these values require the existence of a resisting medium, or of some tangential force producing a similar effect, though varying in amount. It is one of the conditions that add to the probability of the theory of a re-

sisting medium in space, that it furnishes a simple and sufficient cause for this tangential force. But the assumption of such a medium, and its identity with the luminiferous ether, when only the motion of a single body gives evidence of it, and this with a varying coefficient, seems much too general. Fifty years ago Bessel pointed out that there are many other causes which may produce the diminution of the period observed in the Encke comet, and he called special attention to the repulsive action of the sun on the matter of a comet when near its perihelion. In recent years we have seen several instances of a similar action, sometimes proceeding so far as to disintegrate the nucleus of the comet. It seems to me, therefore, that the views of Bessel deserve to be reconsidered, especially since the latest investigations on the motions of different comets have failed to confirm the theory of a resisting medium in the planetary spaces.

The following is an outline of Bessel's argument (*Astr. Nach.*, Bd. 13, p. 345): Let V be the velocity of a body in its orbit round the sun, r its radius vector, and a the semi-major axis of its orbit. If m be the mass of the sun plus the mass of the body, we have the well known equation,

$$V^2 = m\left(\frac{2}{r}-\frac{1}{a}\right).$$

Take the axis of coördinates in the plane of the orbit, and the major axis of the ellipse for the axis of x; if we put $m = 1$, we have

$$\frac{1}{2a}=\frac{1}{r}-\frac{dx^2+dy^2}{2dt^2}. \qquad (a.)$$

Suppose that the comet throws off in a unit of time a part of its mass, which is to the remaining part as $u : 1$; then in the time dt it will throw off udt. If the velocity of the part thrown off be g, the angle which the direction of the ejected part makes with the radius vector be α, and if the true anomoly of the comet be v, the velocities of the comet along the axes arising from this disturbance are

$$gu\cos(v-\alpha)\,dt, \qquad gu\sin(v-\alpha)\,dt.$$

The values of $\frac{dx}{dt}$ and $\frac{dy}{dt}$ for this instant become

$$\frac{dx}{dt}+gu\cos(v-\alpha)\,dt\ :\ \frac{dy}{dt}+gu\sin(v-\alpha)\,dt.$$

Since r is constant in differentiating for the perturbation, equation (a) gives,

$$d \cdot \frac{1}{2a} = -gu \left\{ \cos (v-\alpha) \frac{dx}{dt} + \sin (v-\alpha) \frac{dy}{dt} \right\} . dt.$$

The polar equation of the ellipse is

$$r = \frac{p}{1 + e \cos v}$$

and we have

$$x = r \cos v : \qquad y = r \sin v.$$

Differentiating these values of x and y, and substituting the values of

$$\frac{dv}{dt} = \frac{\sqrt{p}}{r^2} \quad : \quad \frac{dr}{dt} = \frac{e \sin v}{\sqrt{p}}$$

we have

$$\frac{dx}{dt} = -\frac{\sin v}{\sqrt{p}} \quad : \quad \frac{dy}{dt} = \frac{\cos v + e}{\sqrt{p}}$$

and hence

$$d \cdot \frac{1}{2a} = \frac{gu}{\sqrt{p}} . \{ \sin \alpha - e \sin (v - \alpha) \} . dt,$$

p and e being the semi-parameter and and excentricity of the orbit. Now

$$dt = \frac{r^2}{\sqrt{p}} . dv = \frac{\sqrt{p^3} . dv}{(1 + e \cos v)^2}$$

so that

$$d \cdot \frac{1}{2a} = gup . \left\{ \frac{\sin \alpha - e \sin (v - \alpha)}{(1 + e \cos v)^2} \right\} . dv,$$

or we have finally

$$d \cdot \frac{1}{2a} = gup . \left\{ \frac{\sin \alpha \, dv}{1 + e \cos v} - \frac{e \cos \alpha \sin v \, dv}{(1 + e \cos v)^2} \right\}. \qquad (b)$$

The integral of (b) between the limits v_2 and v_1 gives the variation of $\frac{1}{2a}$ in the corresponding interval. If ε be the excentric anomaly we have

$$\frac{d\varepsilon}{dt} = \frac{1}{r\sqrt{a}}$$

and hence

$$r . dv = \sqrt{ap} . d\varepsilon.$$

The differential (b) takes the form

$$d \cdot \frac{1}{2a} = gu \{ \sin \alpha \sqrt{ap} . d\varepsilon - \cos \alpha \, dr \},$$

and the integral is

$$\Delta \cdot \frac{1}{2a} = gu \left\{ \sin \alpha \sqrt{ap} \cdot (\varepsilon_2 - \varepsilon_1) - \cos \alpha \, (r_2 - r_1) \right\}.$$

The corresponding change in the periodic time is

$$\Delta\tau = -3gua\,\tau \cdot \left\{ \sin \alpha \sqrt{ap} \cdot (\varepsilon_2 - \varepsilon_1) - \cos \alpha \, (r_2 - r_1) \right\}.$$

For a numerical example let $\alpha = 0$, or assume that the matter is thrown off towards the sun. Bessel found from his observations of Halley's comet in 1835 the value of

$$g = 0.03756,$$

the unit of time being

$$\frac{1}{k} = 58.13244 \text{ days},$$

where k is the Gaussian constant. Hence we have

$$\Delta\tau = +\,57185\,(r_2 - r_1)u, \text{ in days.}$$

For Oct. 2 and Oct. 25, $r_1 = 1.08386$; $r_2 = 0.75085$, so that

$$\Delta\tau = -\,19043 \,.\, u.$$

Suppose that during this interval of 23 days the comet threw off daily $\frac{1}{1000}$ part of its mass towards the sun, an amount which Bessel thinks was indicated by observation; we have

$$u = \frac{0.001}{k} = 0.05813244 \,.$$

and the result in this case is

$$\Delta\tau = -1107 \text{ days}.$$

The Halley comet has a period of about 76⅓ years, or 27,900 days, and the major axis is 18.178. On account of the magnitude of these quantities the value of $\Delta\tau$ in this example comes out large, but the numbers are used simply to illustrate a possible case. In order to destroy the influence of $\Delta\tau$ on the periodic time there should be an equal ejection of cometary matter on the other side of the perihelion, but such an equality does not seem probable.

If now we compare the methods of Encke and Bessel we see that the assumption of a resisting medium filling space has the advantage and the attraction which belong to vast and indefinite theories; such, for example, as the nebular hypothesis, and it is not to be expected that such a theory will be given up because a few facts contradict it. There is always a hope that further investigation may reconcile the

facts; but so far the progress of astronomy has weakened, I think, the position taken by Encke with such confidence thirty years ago, and at the present time the astronomical proof of a resisting medium is very slight. On the other hand Bessel has only called attention to a phenomenon which has been observed many times, that is the throwing off of envelopes from the nucleus of a comet, which is one where the velocities of the ejected particles have been measured and their orbits computed. The mechanical action of these masses on the nucleus of the comet is therefore a question that astronomers ought to consider, and one for which they should seek a rational explanation. The only quantity in Bessel's expression for the change in the periodic time that must be assumed is u, the ratio of the mass thrown off to the remaining part. In the example given above this ratio may be taken erroneously, but the distinction between the methods should not be overlooked on account of any numerical error. That a certain part of the comet is ejected is a matter of fact, and if it has a finite ratio to the remaining part the mass and velocity of the ejected part must exert a certain force.

Oct. 15, 1889.

ORMSBY MACKNIGHT MITCHEL.*

J. G. PORTER.†

FOR THE MESSENGER.

To have been the founder of a scientific institution which has now completed nearly half a century of activity and usefulness; to have secured for this institution through his own personal influence and efforts the largest telescope at the time in the western hemisphere, and one of the largest in the world; to have aroused by his eloquence such a widespread interest in the science of the stars that other observatories were organized, and the thoughts of multitudes were elevated above the sordid cares of money getting to the ennobling contemplation of celestial scenery; such are some of the achievements which should cause the name of Ormsby M. Mitchel to be held in lasting honor.

* See frontispiece in this number. † Director of the Cincinnati Observatory.

Born in Kentucky in 1809, when the whole of the west was little more than a wilderness, and losing his father soon afterward, he was early thrown upon his own resources. While he was still a boy the family removed to Ohio and settled in Lebanon, a village not far from Cincinnati, which was afterward the scene of his heroic struggles and brilliant success. Resolving to gain an education, he obtained an appointment to the military academy at West Point through an influential relative of his mother. When that gentleman said to him, "We have had many of our boys go to West Point, but few of them get through," Ormsby drew himself up, looked him in the eye, and replied. "I shall go through, sir!" He was as good as his word. Though one of the youngest of his class he graduated with honor, and was appointed assistant professor of mathematics in the Academy. Afterward he was stationed for a short time in Florida; but soon tiring of the inactivity of army life, he resigned his position and came to Cincinnati, where he commenced the practice of law. In 1834 he was elected professor of mathematics, philosophy and astronomy in the Cincinnati College then just established.

Astronomy was at that time in its infancy in this country. A few observatories, connected for the most part with institutions of learning, and very imperfectly equipped with small and inferior instruments, had already been built; but the energies of the nation were absorbed in developing the grand resources of a new and ever widening territory, and the cultivation of the liberal arts and sciences was mostly left to the established civilizations of the Old World. Still there was already wealth enough in the country, and even in the West to justify an increased attention to higher learning. What was specially needed was some one to interest the people and awake enthusiasm on such subjects. This is what Mitchel did for astronomy. Others have accomplished far more than he in the way of laborious scientific research; but none probably have wielded a more potent influence for the advancement of astronomy in this country than did Mitchel by his matchless eloquence, the echoes of which have not yet died away in the memories of those who heard him.

Becoming deeply interested himself and desiring to lead his students into still more intimate knowledge of the wonders

of the sky, he conceived the idea of erecting an Observatory. It was an arduous undertaking for a man without fortune himself and with no wealthy patron to back his enterprise; and nothing short of indomitable energy and perseverance, coupled with no inconsiderable business tact, could have carried it through to successful completion. He opened his campaign by a brilliant series of lectures which he illustrated with a stereopticon, taking his hearers over the whole range of astronomic discovery, from the rude observations of the primitive gazer upon the Babylonian towers, on down the ever brightening track, till he ushered them into glories which stream upon the vision of him who views the heavens through the modern telescope. At the close of these lectures he laid before the audience his project for securing for Cincinnati an Observatory which should be worthy of the name. The fact was emphasized that in the Old World "monarchs lavished treasures on the temples of science," while here the people must build them; and accordingly his plan was to divide the amount needed into shares of twenty-five dollars each, and each subscriber was to have the privileges of the Observatory. When three hundred share holders had been obtained, the association thus formed sent Professor Mitchel to Europe to make the necessary arrangements for procuring a telescope. After a vain quest in London and Paris, he finally found in Munich in the cabinet of Merz and Mahler, successors of the famous Fraunhofer, the object of his desire, an objective nearly a foot in diameter. To mount this glass would require about ten thousand dollars, a larger amount than had yet been subscribed; but Mitchel believed that the money could be secured, and he ordered the instrument. Before returning to this country he spent some months with Professor Airy, Astronomer Royal of England, whose friendship greatly encouraged and assisted Mitchel in his laborious undertaking.

A commercial depression had come upon the business of the country during his absence in Europe, a fact which much increased the difficulty of raising the payments for the telescope. Moreover a building must be provided for its reception. Even his most enthusiastic friends were troubled by the gloomy state of affairs, and some of them felt too poor to do all that they had promised; but the unwavering faith

and resolution of this heroic man achieved victory in the face of obstacles that would have discouraged a less exalted nature. The munificence of Nicholas Longworth supplied the society with a site for their building unsurpassed in natural advantages by any excepting those of our mountain observatories. Professor Mitchel compares the view with that from the castle opposite the city of Coblentz on the Rhine. The broad sweep of the Ohio around the foot of the eminence, and the city enclosed by the amphitheater of hills, present a prospect never to be forgotten. It is greatly to be regretted that in subsequent years the increasing dirt and smoke of the city rendered a change of location necessary.

The ninth of November, 1843, was a memorable day. John Quincy Adams, then nearly four score, had consented to deliver the oration at the laying of the corner stone; and amid the hush of the vast throng which had assembled on the hill top, he paid a worthy tribute to the "founders of the Observatory, to science, and then to the country he loved, the home of a free, enterprising and intelligent people." The following summer saw the work on the building resumed. During the winter and spring the remainder of the purchase price of the instrument had been raised and sent to Munich. The treasury was empty, but the indefatigable astronomer appeals to the intelligent mechanics of the city. Some of them take stock and pay for it in labor, others in materials; and thus the walls slowly rise, Mitchel himself much of the time working with his own hands. In the early part of 1845 the building was ready for the reception of the telescope which had arrived in February. We can more easily imagine than describe the anxiety and eagerness with which, after successfully completing the work of mounting and adjustment, he turned the immense tube upon the heavenly bodies. Its performance from the first seems to have been entirely satisfactory.

Of the scientific work accomplished by Mitchel there is not very much to be said. His title to fame does not rest upon this, although he seems to have made good use of the telescope during the time that circumstances permitted him to observe with it. Much attention had necessarily to be shown to the stockholders of the astronomical society and their friends. During the first year after the telescope was

mounted five evenings out of the week were devoted to them, and in subsequent years half the evenings. Not long after the completion of the Observatory, moreover, the Cincinnati College burned down, and his salary as professor ceased. As he had agreed to superintend the observatory for ten years without salary, depending on that from the college, he was obliged to give part of his time to maintaining his family. In 1846 he commenced the publication of *The Sidereal Messenger*, the earliest magazine devoted to popular exposition of astronomy. This was successful for a couple of years, but for some reason was then discontinued. In the mean time Mitchel had begun his course of lectures in the great cities of the Union. He first visited Boston, where his success was so marked that he was at once recognized as one of the leading orators of the country. Says one who heard him, "In New York the Music Hall is thronged night after night to hear his impassioned eloquence poured in an unbroken flow of 'thoughts that breathe and words that burn' on the excited thousands. A sublimer spectacle in lecturing was never seen. The object, the theme, the orator, the intellectual audiences, the wrapt attention, the almost painful intensity of feeling, all crown him the prince of lecturers."

With all these interruptions to his strictly scientific work, it is not to be wondered at that he has left no long series of observations behind him. Yet in this department he was not idle. He early undertook, at the suggestion of Airy and Struve, the observation of the double stars in the southern sky. Some of his measures were published at the time in the scientific journals, and others may be found in the publications of the Cincinnati Observatory. The duplicity of Antares was discovered by him in 1846, though it seems that Grant in India had anticipated him by a year or two. Mitchel was one of the first to employ the principles now embodied in the chronograph to the recording of time, though he laid no claims to having originated the idea. In his Popular Astronomy he says:

"In the autumn of the year 1848, the late Professor S. C. Walker, then of the U. S. Coast Survey, was engaged with me at the Cincinnati Observatory in a series of observations for the determination of the difference of longitude between Philadelphia, and Cincinnati. In comparing our clocks with those of Philadelphia, an observer at Philadelphia listening to the clock beat touched the key of the telegraph at every beat, and we received

at Cincinnati an audible tick every second of time, which was carefully noted, and thus our clocks were compared. There were two sources of error in this method of comparison, arising from an imperfect imitation of the clock-beat by the Philadelphia operator, also from our noting the arrival of that beat in Cincinnati. On the 26th of October, 1848, Professor Walker, while conversing on this subject, first presented to me the mechanical problem of causing the clock to send its own beats by telegraph from one station to the other, or what amounted to the same thing, the problem of converting time into space; for in case the clock could send its own beats by telegraph and these beats could be received on a uniformly flowing time scale, the star transit could be also sent by telegraph and received on the same scale, and thus a new method of transits would at once spring from the resolution of the first mechanical problem. I was informed by Professor Walker that the problem had already been presented to others, but so far as he knew, had never been solved. The full value of the idea was at once appreciated; and on the same evening a common brass clock, the only one then in the Observatory, was made to record its own beats by the use of the electro-magnet on a Morse fillet. The problem once solved, nothing more remained than to elaborate such machinery as would render it possible to apply this new invention to the delicate demands of astronomical observation."

In 1860 he was appointed to the directorship of the Dudley Observatory in Albany, but scarcely had he entered upon the position before the breaking out of the Civil War called him to higher duties. His early training at West Point made him feel it only right that he should give his services to the support of the government. How well and nobly he acted his part and gave up his life in the struggle for freedom, is a matter of history. To trace his military career is beyond the scope of this article. Had he no other claims to eminence he would be gratefully remembered as one of the heroic defenders of his country. His pastor in Albany, in a public address, thus refers to him:

"General Mitchel was distinguished in so many departments that I am unable to say whether he was most eminent as an astronomer, a soldier, or a Christian. He certainly presented in a most happy union, scientific culture, earnest patriotism, tender humanity, and devoted piety. His intellect moved among the stars and caught their brilliancy. His thoughts partook of their harmony and grandeur. His discoveries and contributions to astronomical science are alone sufficient to render his name distinguished in the annals of American literature. His popular lectures made him a favorite with all, and inspired the minds of the people with a love for the beauties and sublimities of astronomy and with adoration for the great Creator and His marvellous works. . . . In his death science lost a rare ornament, the army mourned a brave and skillful soldier, humanity wept for an earnest defender and advocate, and the church lost a true Christian and humble follower of our Lord Jesus Christ."

EARTH-TREMORS.

HERBERT A. HOWE.*

FOR THE MESSENGER.

During the month of October just passed, some experiments were made at University Park, a suburb of Denver, to determine the effect of vibrations of the earth caused by trains, teams and men, on images reflected from a mercurial horizon. The reflected images of objects on the roofs of houses were watched with the naked eye, and also through the telescope of an engineer's transit, made by Fauth & Co.; the magnifying power of the latter was about twenty diameters. The observing station was 1,500 feet away from the Denver, Texas and Gulf railroad and 500 feet from the Denver and Santa Fé [narrow gauge]. The soil is a loam several feet deep, and was very dry, the surface being quite hard.

Below is a summary of the results.

1. When a man weighing 135 pounds jumped up from the ground six inches, and came down on his heels, the reflected image quivered, if the man was not more than 125 feet from the mercurial horizon.

2. A team of small horses, attached to a light wagon, and driven at a slow trot, caused disturbances which vanished when the vehicle reached a distance of two hundred feet from the mercury.

3. A pebble half as large as one's thumb, dropped one-eighth of an inch at a distance of one foot, made the reflected image tremble perceptibly to the naked eye. When the pebble was dropped similarly and repeatedly on a little heap of loose earth, no vibration was detected until the earth became packed. The image seemed to leap *away* from the point where the pebble struck.

4. Denver and Santa Fé trains did not shake the image, probably because they ran slowly in approaching the depot.

5. Passenger trains on the Denver, Texas and Gulf made more marked tremors than freight trains of much greater weight. Though the amplitude of vibration of the image was not great, it was seen to increase as the trains approached, and to die away as they receded.

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* Director of the Chamberlin Observatary, University of Denver, Colorado.

6. The horizon was placed on the ground at the bottom of a rectangular excavation 6 feet deep, 16 feet long, and 2 feet 8 inches wide, which was surrounded by a 12-inch stone wall. The transit was above, its tripod resting on the natural surface, and the reflected image was that of the cornice of a house. Pebbles of various weights were dropped repeatedly a distance of 3 feet, striking on the natural surface near the instrument. The point of striking was 8½ feet from the mercury [six feet horizontally and the same distance vertically]. Some of the pebbles caused no tremor that could be seen, others a slight one, and the heavier ones a very marked quivering.

The horizon was then placed on the natural surface at a distance of 8½ feet from the point where the pebbles struck the ground. The same pebbles were again dropped from the same height, but *no shaking of the image could be perceived.* When, however, they were dropped at a distance of six feet from the horizon, the disturbance of the image was a trifle greater than when the horizon was at the bottom of the excavation.

7. The horizon was set on top of the stone wall surrounding the excavation, and the pebbles were dropped *on the wall* at a distance of six feet from the mercury. The tremors were much stronger than before.

8. Two pieces of iron, weighing respectively one and two pounds, were dropped from different heights at various distances from the mercury; the weights were dropped, in each case, at such distances that the vibrations caused were barely preceptible. A discussion of these revealed the following law:

The intensity of vibration varies directly as the potential energy of the suspended weight, and inversely as the square of the distance between the mercury and the point of striking of the weight.

These observations seem to show that greater gain is to be expected from placing the piers of instruments at a distance from disturbing influences, than from sinking their foundations deep in the earth. They are somewhat at variance with the first page of Loomis's Practical Astronomy.

NOTE ON THE PHOTOGRAPHIC SPECTRA OF URANUS AND SATURN.*

WILLIAM HUGGINS, D. C. L., LL. D., F. R. S., AND MRS. HUGGINS.

Uranus.—In 1871 I had the honor to communicate to the Royal Society an account of the examination of the visible spectrum of Uranus.† The visible spectrum of this planet is remarkable, as it is seen to be crossed by several strong lines of absorption. Six of these dark bands are shown in a diagram which accompanies the paper,‡ and their approximate positions in the spectrum are given. The spaces between the dark bands appear bright by contrast, and might suggest at first sight bright bands. I was unable to use a slit sufficiently narrow to enable me to determine whether the bright parts of the spectrum contain the Fraunhofer lines, which would be the case if Uranus, like the other planets, shines by reflected solar light.

The spectrum of this planet was carefully examined in 1872 by Vogel,§ whose results are in accordance with my earlier ones. He observed some fainter lines or bands, in addition to those given in my paper. Vogel was unable to obtain evidence of the Fraunhofer lines. His observations agree with mine in placing a dark band at the position of F in the solar spectrum.‖

In consequence of the Fraunhofer lines not having been seen, a presumption has arisen that Uranus may shine, in part at least, by emitted light.

It appeared to me that this question might be answered by photography. With an exposure of two hours, I obtained on June 3 a photograph of the spectrum of the planet from a little above F to beyond N in the ultra-violet. A pair of sky spectra, one on each side of the planet's spectrum were taken on the same plate.

The spectrum of Uranus, though fainter, shows all the chief Fraunhofer lines seen in the comparison spectra, and is clearly solar. I have not been able to detect any indications

* Read before the Royal Astronomical Society.
† 'Roy. Soc. Proc.,' vol. 19, p. 488.
‡ To be published in next MESSENGER.
§ 'Untersuchungen uber die Spectra der Planeten,' Leipzig, 1874.
‖ Measures of some of the bands were made at Greenwich in 1882. See 'Greenwich Spectroscopic and Photographic Results,' 1882, p. 33.

of bright lines, nor of any strong bands or groups of absorption, such as those in its spectrum from F to C.

There can be no donbt that the spectrum of Uranus, at least, from a little above F to beyond N in the ultra-violet, is due to reflected solar light. I have not yet been able to re-examine the visible spectrum of the planet.

Saturn.—In 1864, I gave an account of an examination of the visible spectrum of this planet and its rings. In my paper on the "Photographic Spectra of Stars,"* I described the photographic spectra of Venus, Jupiter, and Mars. About a year later I took a photograph of the spectrum of Saturn and his rings, but as it did not present any new features, but was purely solar, I have not given any description of it.

The favorable position of Saturn this year for obtaining a photograph in which the spectra of the ansæ of the rings could be seen distinct from the spectrum of the ball and of the part of the ring crossing it, determined me to take some photographs of the planet and its rings.

I have adopted the plan described in 1880, in which the planet is photographed while the sky is sufficiently bright to give a faint daylight spectrum on the plate. Any additional lines or other modifications of solar light due to the planet's atmosphere can in this way be easily detected.

In the photographs taken this year the slit was so placed upon Saturn that the spectrum consists of three distinct parts, the middle part being formed by the light from the ball, and the part of the ring across it, and on both sides of this spectrum the spectra of the ansæ. The planet was kept upon the same part of the slit with sufficient exactness to keep these three spectra distinct, and from encroaching upon each other, and therefore if any difference existed between them it could be detected.

The exact correspondence of the Fraunhofer lines in the spectrum of the planet and its rings with those of the sky spectrum is clearly shown, but I am unable now, as I was in 1881, to detect any lines, dark or bright, other than those which are also present in the sky spectra. The spectrum on the plate extends from a little above F to beyond N in the ultra-violet.

* 'Phil. Trans.,' 1880, p. 669.

I am trying to obtain enlargements of the spectra of Saturn and Uranus to serve as illustrations to this note. If they can be done so as to admit of reproduction, I will do myself the honor to present them to the Royal Society.

[We have observed since, the visible spectrum of Uranus, but under unfavorable conditions, the planet being low and the sky not dark. These observations confirm me strongly in the opinion I formed in 1871 that the brighter parts of the spectrum appear so as an effect of contrast, and do not represent emitted light. In the moments of best vision the spectrum on both sides of brighter parts appeared to be darkened by groups of lines which give a heightened effect by contrast to the less obscured parts between them.

At moments, we were conscious of dark lines crossing the spectrum, but the unfavorable conditions under which the observations were made prevented us from ascertaining by measurement or otherwise, whether any of these lines were Fraunhofer lines.—July 5.]

OBSERVATORY LOCAL PATRONAGE THREATENED.

It is well known to all our readers that it has been the practice of astronomical Observatories, from the first, to give attention to the matter of keeping accurate time, and often to distribute it to local customers for whatever pay, in money, could be properly secured. These customers have usually been jewelers, hotels, banks, business houses, railroad companies and other forms of business depending more or less upon the use of accurate time. Outside of voluntary gifts by the few friends who might be interested, this local time service for the public has been the only means that Observatories have had by which to secure a little money to pay running expenses. The endowed Observatory is the exception and not the rule. The cost of erecting a good working Observatory is considerable, but the expense of maintaining one and prosecuting work therein for years is even more. Now, it has happened during this last year that this old and time-honored custom of having the benefit of this local time service from local patronage has been curiously invaded, and very persistent attempts have been made wholly to divert

this local patronage from the local Observatory to the use and benefit of a merely commercial corporation, and that, too, one of the largest corporations of the kind in the United States. The general plan of work to accomplish this important commercial end was about as follows: By printed circulars the general officers of the various railroad companies were informed that Observatory time would be furnished for the use of railroad companies at much cheaper rates than were being paid to local Observatories. To this appeal little or no attention was paid by those it was intended to interest, and the next step was to buy, or get control of, certain clocks having self winding and synchronizing attachments, and then offer to rent these clocks at very low figures to all parties interested in using accurate time, and already using local Observatory time in various parts of the United States. The point in this step seemed to be to control all good patents, and then offer their use so low that Observatories having local time patronage would be unable to compete for it longer. To make this step a final one in this large commercial transaction, and give it character everywhere in the country, the general officers of this commercial company (which we will now name as the Western Union Telegraph Company), interviewed the Superintendent of the U. S. Naval Observatory, and sought and obtained of that officer, as they say, certain definite contract relations by which the telegraph company should have the privilege and right to use the time of the United States Naval Observatory for its own uses in commercial sale and barter. This is no secret on the part of the telegraph company, for the writer has heard a Vice President of the company very freely speak of the matter, and so have others. What arrangements the Superintendent of the United States Naval Observatory entered into with the telegraph company named, by which it was deemed wise to permit this kind of an attack to be made on the local financial support of the Observatories of the country, it is not apparently very easy to find out. So far as we know, all fair and courteous endeavor to get at the real gist and meaning of this rather extraordinary transaction between a government official and a private telegraph company, by which the rights and interests of educational institutions of the land are put in hardship with the

prospect of financial loss, to increase the business of a private telegraph company in lines of business not naturally its own, seems to us certainly proper matter for public notice and public record. It is very hard to believe statements on good authority that have furnished some of this information; and we shall be more surprised than ever if it shall turn out that the professors of the United States Naval Observatory are in any way giving countenance to any such scheme as this.

In view of the palpable wrong in all this procedure, it is suggested that the Directors of Observatories and others interested take up this matter in earnest, and by judicious and general concert of action, seek promptly and thoroughly to right whatever of wrong may oppose the just advancement of our science by the encroachment of unworthy or mercenary projects. A convention in the interest of this movement, called at an early date to formulate a plan for general use, seems a feasible and natural step as a first one to take. General correspondence is solicited.

DOUBLE SHOOTING STARS.

DR. LEWIS SWIFT.

For The Messenger.

The phenomenon of a double shooting-star seen passing through the field of a telescope must, I judge, be exceedingly rare, as, during the past thirty-two years, I have seen but four,—two several years since, with my 4½-inch telescope, and two more recently with my 16-inch. Of the former two, if I remember rightly (having mislaid the record), but a day or two elapsed between their appearances, and, very singularly, the second traveled not only over the same path (across Draco), but in the same direction, northeasterly, as the first. In neither case did one component precede the other, but passed through the field side by side, at a right angle to the direction of motion. Had they not done this the phenomenon might have been ascribed to an optical illusion caused by persistence of vision or something akin to it. Between the components of both of these was a strongly marked nebulous ligament, in form like a dumb-bell, connecting them together.

On the evening of September 18, 1889, one traversed the field of the 16-inch glass from east to west, crossing the square of Pegasus, presenting two small disks without ligamental band between, and resembling, as to distance apart, magnitude, and general appearance, the star Castor.

On the night of October 24 another was seen to pass across the neck of Pegasus with components tied together like those first described, and the distance between them was estimated to be about 15 seconds of arc. It suggested Gamma Delphini in appearance. Its motion was exceedingly rapid.

We have double stars, double clusters, double comets, and double nebulæ, and now the list of doubles must be extended to the meteors.

A few evenings ago I had the pleasure of seeing what I had never before witnessed, namely, a serpentine shooting star, which careered across the field from west to east. Two or three small curvilinear deviations were observed as it moved along, and, when it had spanned almost two-thirds of the diameter of the field, it gracefully turned to the south, curving like a sickle blade, and disappeared from view.

I have read of meteors of this sort having been occasionally observed, but has any other astronomer ever seen a double shooting-star?

WARNER OBSERVATORY, Rochester, N. Y.,
November 18, 1889.

DR. PETERS' STAR CATALOGUE.

In the March number of this journal, an account was given of the case of Dr. C. H. F. Peters, Director of the Astronomical Observatory of Hamilton College, Clinton, N. Y., against Mr. Charles A. Borst, Fellow at Johns Hopkins University, to obtain possession of the manuscripts containing over 30,000 stars arranged for a star catalogue, which came up for hearing before Justice Williams of the Supreme Court at Utica, N. Y., on the last day of January of the present year. It appears that the manuscripts were made by Mr. Borst, aided by his sisters, and that they contain the

positions of 35,608 stars reduced to the epochs of 1850 or 1875, and arranged in the order of their right ascension. These manuscripts number 3,572 pages, 900 of which are double folio in size, and show upwards of 7,000,000 figures. Dr. Peters claimed that Mr. Borst did the work of compiling and computing while he was employed in the Observatory, on a salary paid by himself, and that therefore the property belongs to him.

On the other hand, Mr. Borst claims that he did the work on the catalogue outside of his labors at the Observatory, and that most of the computations were made by persons at his request without the direction of Dr. Peters.

The testimony in the case showed that the labor put on this catalogue would have cost at least $12,000. The progress of the trial developed large interest in scientific circles because of the new questions raised in a court of justice, and the prominence of some of the witnesses.

The decision of the case was rendered by Justice Williams November 8, in favor of Dr. Peters, and the principal points were substantially as follows:

1. The court held that the manuscripts and the work on them did not belong to Hamilton College nor to Litchfield Observatory, because the compensation paid to Dr. Peters since 1858 was deemed too small to cover the work of literary authorship in justice to him. This point was stated at length, and the legal authorities for the position were cited.

Dr. Peters is Professor in Hamilton College and Director of the Litchfield Observatory. On the relation of his official position to that of authorship the court held as follows:

In this case there seems to have been no agreement that any production of these parties as authors should be the property of the Observatory or the College. The plaintiff acted as professor and teacher in the College, and had the custody of the Observatory and the instruments and property connected therewith, and the defendant acted as his assistant, and while the Observatory and College might enjoy the benefits to be derived from having such men in their employ, men who might become eminent and distinguished by reason of the mental labor and results they achieved, it can hardly be claimed the Observatory or College would become the owners of the works they might, as authors, produce and publish to the world. The property in these works, so long at least as they remain unpublished, belonged to the authors and to them alone. So that the real question to be determined here, is not whether the Observatory or College was the

owner of these chattels, the book and manuscripts, in question, but which one of these two parties was the owner thereof, and therefore entitled to their possession when this action was commenced.

In this view of this case, I think it must be said the book, exhibit 2, was the property of the plaintiff and he was entitled to its possession. It was his in 1884, before the preparation of the other exhibits in question was made, and it is not claimed he ever gave it to the defendant, or parted with its possession so as to prevent his demanding, and being entitled to its return at any time.

2. The second point related to the ownership of certain parts of this manuscript catalogue, whether they belonged to Dr. Peters as plaintiff or to Mr. Borst as defendant. After speaking of the various exhibits into which the manuscript was divided, and the evidence of ownership belonging to each, the court finally concludes as follows:

I am impressed in the examination of this case with the truthfulness of the plaintiff's claim—that he regarded this catalogue all along as his own work; that he never consented to surrender it to the defendant; that he intended to give defendant full credit for all he did upon or with reference to it; but that the defendant, as he became familiar with the work and learned how to manage its details, conceived the design of appropriating the whole work to himself, and depriving the plaintiff of all credit for or reputation growing out of it. That then it was that he threw into the work all his executive ability, and that of his sisters, with a view to overwhelming the plaintiff, and creating the impression and belief in the public mind that it was his own personal work, with which the plaintiff had practically nothing to do. In this view I must hold that the exhibits in question, including exhibits 4, 5 and 6, were, at the time of the commencement of this action, the property of the plaintiff, rather than the defendant, and that plaintiff is entitled to recover them in this action.

3. The third is also an interesting one, as indicating a ground in such a case for legal damages. On this point the court said:

In view of the evidence in the case, as to the value of the papers, I can not fix this value very definitely, but I should say exhibit 2 was worth $250; exhibits 4 and 5 each $500; exhibit 6, $1,000; and exhibit 8, $10, making in all, $2,260.

Damages for detention will be fixed at the amount of interest on above values, and from time of commencement of action.

The above citations from Judge Williams' decision in this now prominent case are taken from the *Utica Morning Herald* (Nov. 9) and are given somewhat at length, because it is the only case of the kind known to us in the annals of astronomical science. There may have been others like it,

but, if so, we do not know of them. Those who may be interested in the legal or ethical parts of this case and its decision should read it entire.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

Mercury is in the descending node of his orbit, passes aphelion Dec. 7, and, at the same time, is in superior conjunction with the sun. On Dec. 26 he is in conjunction with Jupiter, and on the 27th he will be in greatest heliocentric latitude south. His position for the whole month is as unfavorable for observation as it well could be.

Venus is a morning planet during this month and will be in conjunction with the moon Dec. 21.

Mars will be a morning star for this month and next. He is in the constellation of Virgo, and during the first part of December he will pass a little north of the bright star Spica, thence to the south and east entering Libra first days of next month. His declination will then be eleven degrees south, and so less favorable for observation.

Jupiter's position is becoming unfavorable, because so low in the southwestern sky at early morning. The leading article for November in *l'Astronomie* (French), by editor Camille Flammarion, is about Jupiter. It is accompanied by six illustrations of telescopic views of the planet's disk, showing the prominent features of the surface markings. In A. N. 2928 is a brief article on the occultation of Jupiter by the moon, Aug. 7, 1889, by O. Tetens of the Observatory at Bothkamp, accompanied by a fine plate showing the planet Jupiter about one-third occulted. Two great belts on the planet's surface are seen, and another singular phenomenon which we do not remember to have noticed before. We refer to a kind of penumbral haze, about eight minutes in breadth, on the disk of the planet, extending beyond the limb of the moon, and concentric with it. The shade seems to be about one-half as dark as belts of the planet's disk.

Mr. Tetens' observation is given below in his own language as translated from the German:

"Although the occultation of Jupiter which took place the 7th inst., by the moon, could be followed only in part on account of unfavorable weather here in Bothkamp, nevertheless I communicate my observations in regard to it, on account of a peculiar appearance noticed by me during the reappearance of the disk of the planet, with the supposition that the phenomenon was also observed at other places.

What is most important in this unexpected observation consists in this, that upon the disk of Jupiter, which was quite dark in comparison with the moon, during the last two thirds of its emersion there showed itself a tolerably sharply defined shadow; which, fixing itself in a width of about one-fifth of the diameter of Jupiter from the southern to the northern limit of the planet on the edge of the moon, did not seem to change in the course of the appearance which lasted more than a minute. The light and dark zones of the planet could be seen with lessened intensity in the extent of the shadows, but with perfect distinctness. Within the limits of the shadow imposed on Jupiter, a parallelism, with the outlines of three mountains somewhat perpendicular near the edge which were projected on the disk, was not seen.

During the last seconds of the occultation I was obliged, in order not to lose the desired chronometrical observation of the four contacts, to turn my attention from the shadow. It was impossible to further locate the cause of this appearance as there was no other observer at hand, and during the short duration of the appearance the change of the lens or of the entire instrument did not seem practicable.

Nevertheless I believe that circumstance dare not be suppressed. The observation was made at the time of the following clock observations and the photographic impressions with an 11 inch refractor. A magnifying power of about 270 diameters was applied for the ocular observation, the photographic impressions were taken in the focus. The mechanism was adjusted during the whole time according to the movement of the moon. The time stated indicates star time. The added probable errors depend on estimations which were made at the time of the observation.

h m s s	
16 56 30	Jupiter is entirely visible through the clouds.
17 2 30 ± 2	Jupiter, of which a few seconds before a very narrow segment was visible through the clouds, disappears entirely.

h	m	s	s	
17	7	17		Small rift of the clouds; the second satellite seen two minutes before is now hidden.
17	7	30		It begins to rain; the roof is closed.
17	15	35		Through the door leading to the platform the fourth satellite can no more be seen with a previously arranged Fraunhofer 3-inch glass.
17	57	23	± 2½	was estimated as the time of emersion of the third satellite.
17	57	31		Its observed disappearance and its suddenness.
18	4	57	± 1	Emersion of Jupiter. exterior contact.
18	9	32	± 1½	Emersion of Jupiter, interior contact.
18	4	1	± 4	Half of Jupiter has reappeared.
18	4	57	± 1½	Emersion of the second satellite.
18	26	40 to 43		and
18	27	40 to 43		Two photographic impressions were received on the same plate. With the aid of a magnifier the first impression shows two dark equatorial bands to be clearly seen, and also the light band which borders on the south on the most southerly of those two; on the other hand no trace of the satellites is visible.

Saturn. The chief thing of interest in recent Study of Saturn comes from Lick Observatory, and is the work of astronomer Keeler by the aid of the spectroscope. It will be remembered that Mr. Lockyer in A. N. No. 2881 published a note on the spectrum of the rings of Saturn which was intended to strengthen his view of their origin as meteoric. The acknowledged meteoric constitution of the rings of Saturn made it important to obtain a photograph of their spectrum to learn, if possible, whether collisions were of sufficient intensity to produce incandescent vapors. A fine photograph of the spectrum of the rings was obtained by the Henry Brothers, Paris, which showed that the rings were not only more luminous than the planet (already visually known), but also that "this is truer for the blue light than for visual rays." There was evidence of bright lines in the photograph, and it was this point which Mr. Lockyer wished to emphasize and bring to the attention of astronomers generally. He did not claim to have established the fact.

In April and May last Mr. Keeler made a study of the rings with the different spectroscopes belonging to the Lick Observatory, but although careful search was made for the bright lines on every available opportunity they were not found, and he thinks the probability of their existence extremely small, as he reports in a very instructive article in A.N., No. 2727. A further objection is that if the rings were self luminous, and that this was the cause of the difference in brightness between the rings and the planet, then the

rings ought to be seen in the shadow of the planet. That point is well made. Mr. Keeler is very careful to say that his observations, favorable or unfavorable, would not be conclusive evidence against the photographic process at all, because its long exposures can register the action of light too small to affect the eye.

Uranus is a morning star and is northeast of Spica in the constellation of Virgo, moving slowly to the southeast. He will be in conjunction with the moon Dec. 17, the planet then being 4° 41′ south.

The planet Uranus has also been a favorite object of late for the work of the spectroscope. Mr. Lockyer gave a note to A. N. No. 2904, in which he suggests that the apparent dark bands in the spectrum of this planet which have been mapped by Huggins and Vogel are in all probability not due to the absorption of any known substances, but require some other explanation. He suggests that it is really a radiation spectrum, the apparent dark bands simply indicating defect of radiation in the region where they occur, and that the bright flutings which appear in the spectrum may require a reconsideration of the prevailing ideas of the constitution of the planet. In reply to this Mr. Keeler says in A. N. 2927, that on examining the spectrum of Uranus April 26, 1889, with 36-inch equatorial of Lick Observatory, he found that the brightness of certain places in the yellow and green with a low power and small dispersion certainly gave the impression of self-luminosity, but that later study led him to change his mind. His reasons are as follows:

"1. The appearance of the spectrum with a moderate dispersion is more like that of a continuous spectrum crossed by absorption bands than of a fluted spectrum with dark spaces. The bright places do not border sharply on the dark bands, but are separated from them by less luminous portions into which they gradually merge on both sides. The light curve would therefore have rounded maxima at these points, and not fall off abruptly, as in a fluted spectrum. 2. The great band at $\lambda = 618$ is, according to my measures, as well as those of other observers, exactly coincident in position with the great band in the red in the spectrum of Jupiter and Saturn, this band showing a regular gradation in depth with increasing distance of the planet

producing it from the sun, and in Jupiter and Saturn the band is undoubtedly due to a surrounding absorptive atmosphere. The same band probably appears in the spectrum of Neptune, and analogy points to an identity of origin. It is true, however, that the other great bands in the spectrum of Uranus have no counterpart in the spectra of the interior planets. The band at *F* in the spectrum of Uranus is also an undoubted absorption band. If then two of the prominent bands are due to absorption, it is natural to suppose that the others are also, and that the older views in regard to the nature of the spectrum are correct."

Neptune is in good position for observation for the entire night. He has just passed opposition to the sun, and is between the Pleiades, and Aldebaran in the constellation of Taurus. He will be in conjunction with the moon Dec. 5, the planet being almost one degree to the south of the moon.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
MERCURY.					
Dec. 25	19 03.5	−24 50	8 29 A.M.	12 45.6 P.M.	5 02 P.M.
Jan. 5	20 18.0	−21 30	8 44 "	1 16.6 "	5 50 "
15	21 07.4	−16 38	8 31 "	1 26.7 "	6 22 "
VENUS.					
Dec. 25	17 21.0	−22 49	6 37 A.M.	11 03.5 A.M.	3 30 P.M.
Jan. 5	18 21.3	−23 29	6 57 "	11 20.3 "	3 43 "
15	19 16.0	−22 49	7 09 "	11 35.4 "	4 02 "
MARS.					
Dec. 25	13 39.7	− 8 49	1 54 A.M.	7 22.9 A.M.	12 51 P.M.
Jan. 5	14 03.3	−11 00	1 44 "	7 03.0 "	12 22 "
15	14 24.5	−12 51	1 31 "	6 43.0 "	11 53 A.M.
JUPITER.					
Dec. 25	19 11.1	−22 38	8 26 A.M.	12 53.2 P.M.	5 21 P.M.
Jan. 5	19 22.1	−22 19	7 52 "	12 21.0 "	4 50 "
15	19 32.1	−21 59	7 21 "	11 51.6 A.M.	4 22 "
SATURN.					
Dec. 25	10 25.0	+11 34	9 15 P.M.	4 04.6 A.M.	10 55 A.M.
Jan. 5	10 23.8	+11 44	8 30 "	3 20.1 "	10 11 "
15	10 22.0	+11 57	7 48 "	2 39.0 "	9 30 "
URANUS.					
Dec. 25	13 37.7	− 9 33	1 56 P.M.	7 20.8 A.M.	12 46 P.M.
Jan. 5	13 38.8	− 9 39	1 14 "	6 38.6 "	12 04 "
15	13 39.6	− 9 43	12 35 A.M.	6 00.1 "	11 25 A.M.
NEPTUNE.					
Dec. 25	4 02.4	+18 59	2 19 P.M.	9 43.0 P.M.	5 07 A.M.
Jan. 5	4 01.5	+18 57	1 35 "	8 58.8 "	4 22 "
15	4 00.8	+18 55	12 55 "	8 18.8 "	3 42 "
THE SUN.					
Dec. 25	18 18.4	−23 23	7 36 A.M.	12 00.6 P.M.	4 25 P.M.
Jan. 5	19 07.0	−22 34	7 37 "	12 05.8 "	4 34 "
15	19 50.4	−21 02	7 35 "	12 09.8 "	4 45 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
Jan. 3	*o* Tauri	6	8 54	50	10 17	276	1 23
6	7 Cancri	6½	9 26	162	9 52	199	0 26

Phases of the Moon.

			Central Time. d h m
Last Quarter	1889	Dec.	15 8 58 A. M.
New Moon	"	"	22 6 53 A. M.
First Quarter	"	"	28 11 16 P. M.
Full Moon	1890	Jan.	5 11 37 P. M.
Last Quarter	"	"	14 12 33 A. M.
Perigee	"	Dec.	22 7 4 P. M.
Apogee	"	Jan.	6 6 5 A. M.

Elongations and Conjunctions of Saturn's Satellites.

[Central time; E = east elongation; W = west elongation; I = inferior conjunction (north of planet); S = superior conjunction (south of planet.)

JAPETUS.

Dec. 15, I. Jan. 3, W.

TITAN.

Dec. 18	10 P. M.	I.	Dec. 30	9 P.M.	E.	Jan. 11	6.2 P. M.	S.
22	10 P. M.	W.	Jan. 3	7.3 P.M.	I.	15	5.6 P. M.	E.
26	10 P. M.	S.	7	6.8 P.M.	W.			

RHEA.

Dec. 16	10.1 P.M.	E.	Dec. 30	11.2 A.M.	E.	Jan. 12	12.0 midn.	E.
21	10.4 A.M.	E.	Jan. 3	11.3 P.M.	E.			
25	10.8 P.M.	E.	8	11.7 A.M.	E.			

DIONE.

Dec. 16	6.1 A.M.	E.	Dec. 27	4.8 A.M.	E.	Jan. 7	3.2 A. M.	E.
18	11.8 P.M.	E.	29	10.4 P.M.	E.	9	8.8 P. M.	E.
21	5.5 P.M.	E.	Jan. 1	3.8 P.M.	E.	12	2.5 P. M.	E.
24	11.1 A.M.	E.	4	9.5 A.M.	E.	15	8.1 A. M.	E.

TETHYS.

Dec. 16	2.6 P.M.	E.	Dec. 27	10.4 P.M.	E.	Jan. 8	6.1 A.M.	E.
18	11.9 A.M.	E.	29	7.7 P.M.	E.	10	3.4 A.M.	E.
20	9.3 A.M.	E.	31	5.0 P.M.	E.	12	12.7 A.M.	E.
22	6.6 A.M.	E.	Jan. 2	2.2 P.M.	E.	13	10.0 P.M.	E.
24	3.9 A.M.	E.	4	11.5 A.M.	E.	15	7.3 P.M.	E.
26	1.2 A.M.	E.	6	8.8 A.M.	E.			

Still Another Comet.—At about 10 o'clock on Saturday evening last, while engaged in nebular work, I ran upon a nebulous object having a cometary appearance. As the seeing was poor, and the object so near the naked-eye star Xi Pegasi as to be difficult of observation, and to render impossible accurate bisection with the wires of the eye-piece, I made from the circles the following approximate position: Right Ascension, 22*h* 40*m* 35*s*; Declination, north, 11° 35′;

and described it as "Pretty faint, large, little elongated, cometary, and preceding Xi Pegasi 40*s*, a little south." Inasmuch as Sir William Herschel had two nebulæ near, which I was unable to find, and as in 30*m* no motion was detected, I came, though not without misgiving, to the conclusion that this was, probably, one of his, presumably the brighter of the two. The place of my suspect did not, however, agree with his; but this is a not uncommon occurrence. Last evening, with the seeing moderately good, I again essayed an observation of the suspicious body, which was missing. A search revealed on the other side of the star a similar object distant 75*s*. The distance in R. A. in both cases was determined by counting the clicks of a sounder beating sidereal seconds. A bank of cloud low down in the southwest threatened interference, so as quickly as possible I determined its position from the circle reading, making it at 6*h* 45*m*, R. A. 22*h* 42*m* 25*s* + 11° 50′ 30″ allowing for refraction in Dec. Motion having been observed I hastened to the telegraph office and announced its discovery to Professor Pickering with injunction to "cable." Returning home I secured another hasty observation, but the sky suddenly clouded.

LEWIS SWIFT.

Warner Observatory, Rochester, N. Y.,
Nov. 18, 1889.

Ephmeris of the Brorsen's Comet.

1889 G. M. T.	App. α h	m	s	App. δ °	′	log. r	log. Δ	L.
Dec. 1	22	16	6	−42	33.4			
2		17	0	42	17.3	0.1854	0.1832	0.18
3		17	56	42	0.9			
4		18	54	41	44.4			
5		19	54	41	27.7			
6		20	57	41	10.8	0.1709	0.1799	0.20
7		22	1	40	53.6			
8		23	8	40	36.3			
9		24	16	40	8.7			
10		25	27	40	0.9	0.1557	0.1759	0.22
11		26	40	39	42.8			
12		27	55	39	24.6			
13		29	11	39	6.1			
14		30	30	38	47.4	0.1398	0.1710	0.24
15		31	50	38	28.5			
16		33	12	38	9.3			
17		34	36	37	49.8			
18		36	2	37	30.1	0.1230	0.1652	0.26
19		37	29	37	10.1			
20		38	58	36	49.8			
21		40	29	36	29.2			

1889 G. M. T.	App. α h m s			App. δ ° ′		log. r	log. Δ	L.
22		42	1	36	8.4	0.1054	0.1584	0.29
23		43	35	35	47.2			
24		45	10	35	25.8			
25		46	47	35	4.1			
26		48	26	34	42.0	0.0869	0.1507	0.33
27		50	6	34	19.6			
28		51	48	33	56.8			
29		53	32	33	33.6			
30	22	55	17	−33	10.0	0.0675	0.1420	0.38

Elements and Ephemeris of Comet f 1889 (*Swift*). A telegram from Rochester, received November 18, announces the discovery of a comet by Prof. L. Swift, the position being the following: 1889, November 17*d* 6*h* 45*m* (probably Eastern Standard Time). R. A. 22*h* 42*m* 25*s*. Decl. N. 11° 51′.

The comet has been observed on November 18 and 22 at Harvard College Observatory by Mr. Wendell, and at Lick Observatory by Mr. Barnard.

The Lick position, communicated by telegraph, is as follows: 1889, Nov. 20.6704, Gr. M. T. R. A. 22*h* 49*m* 19.0*s*. Decl. + 12° 45′ 52″.

From the two Cambridge positions, kindly furnished by Professor E. C. Pickering, and that obtained at Lick, the Rev. George M. Searle, of St. Thomas College, Washington, D. C., has computed the following elements and ephemeris:

ELEMENTS.

$$T = 1889,\ \text{December } 1.6136,\ \text{Greenwich M. T.}$$

$$\left.\begin{aligned} \omega &= 74^\circ\, 17'.8 \\ \Omega &= 324\ \ 48\ .9 \\ i &= 10\ \ 58\ .2 \end{aligned}\right\}\ 1889.0$$

$$q = 1.4294$$

Middle Place (O—C), $\Delta\lambda \cos\beta = +\,28''$ $\Delta\beta = -\,3''$

EPHEMERIS.

Gr. Midnight 1889.	R. A. h.	m.	s.	Decl. °	′	log Δ	Light.
November 26	23	3	3	+14	28.4	0.8979	0.96
30		13	25	15	40.3	0.9041	0.94
December 4		24	28	16	51.9	0.9110	0.91
8	23	36	9	+18	3.4	0.9188	9.89

Light at discovery = 1 .

The small inclination gives considerable probability of periodicity; the sign of the discordance for the Middle Place also seems to point the same way.—*Science Observer.*

Ephemeris of Comet II 1889, (Barnard, March 31).

1889 G. M. T.	App. α h m s	App. δ ° ′	log. r	log. Δ	L.
Nov. 22	0 28 2	−17 25.4	0.4644	0.3679	0.83
23	26 3	17 25.7			
24	24 8	17 25.6			
25	22 17	17 25.2			
26	20 29	17 24.7	0.4684	0.3862	0.74
27	18 45	17 23.9			
28	17 5	17 22.8			
29	15 28	17 21.5			
Dec. 30	13 55	17 20.0	0.4725	0.4043	0.67
1	12 25	17 18.3			
2	10 58	17 16.3			
3	9 34	17 14.3			
4	8 13	17 12.0	0.4765	0.4221	0.61
5	6 56	17 9.7			
6	5 41	17 7.1			
7	4 29	17 4.4			
8	0 3 20	−17 5.1	0.4808	0.4395	0.55

E. Milosevich in A. N., No. 2931.

The equations, $x^2 + y = 7$; $x + y^2 = 11$, should never be classed with elementary quadratic equations. I beg leave to assure the student of elementary algebra that he is perfectly right in finding them difficult to solve, for the reason that they cannot be solved at all by a correct application of the principles of elementary algebra.

Eliminating y, the equation for x becomes $x^4 - 14x^2 + x + 38 = 0$; which being of the fourth degree will be satisfied by four different values of x (the numerical values of x being best found by a tedious process of trial;) and then to every value of x will correspond a particular value of y. In this manner the following approximate values were found.

	x	y	x^2	y^2
1	+ 2.0000	+ 3.0000	+ 4.0000	+ 9.0000
2	+ 3.1313	− 2.8051	+ 9.8051	+ 7.8687
3	− 3.2832	− 3.7793	+ 10.7793	+ 14.2832
4	− 1.8481	+ 3.5844	+ 3.4156	+ 12.8481

CLEVELAND KEITH.

Another Solution. Allow me to observe that Mr. Myers' solution in Number 79 of the MESSENGER is not quite satisfactory. From the equations $x^2 + y = 7$, $x + y^2 = 11$, he obtains virtually $(x + \frac{1}{2})^2 + (y + \frac{1}{2})^2 = (\frac{5}{2})^2 + (\frac{7}{2})^2$, and then *assumes* that $(x + \frac{1}{2})^2 = (\frac{5}{2})^2$, and $(y + \frac{1}{2})^2 = (\frac{7}{2})^2$.

Why should he not as well assume $(x + \frac{1}{2})^2 = (\frac{7}{2})^2$, and

$(y + \frac{1}{2})^2 = (\frac{5}{2})^2$? From these he could not find values of x and y that satisfy the given equations as they stand. Again, on Mr. M.'s assumption the results should be $x + \frac{1}{2} = \pm\frac{5}{2}$, $y + \frac{1}{2} = \pm\frac{7}{2}$; hence $x = 2$ or -3, $y = 3$ or -4. The values $x = -3$, $y = -4$ ought to satisfy the given equations, which they will not.

A correct solution of the equation is as follows: Eliminating y by substitution gives

$$x^4 - 14x^2 + x + 38 = 0. \qquad (1).$$

This equation has *four roots* or values of x, and from them *four* corresponding values of y may be found from the equation $y = 7 - x^2$. Equation (1) may be written

$$x^4 - 2x^3 + 2x^3 - 4x^2 - 10x^2 + 20x - 19x + 38 = 0,$$
$$\therefore x^3(x-2) + 2x^2(x-2) - 10x(x-2) - 19(x-2) = 0,$$
$$\therefore (x-2)(x^3 + 2x^2 - 10x - 19) = 0$$

Hence, by the Theory of Equations,

$$x - 2 = 0, \text{ and } x^3 + 2x^2 - 10x - 19 = 0. \qquad (2).$$

$\therefore x = 2$, and $y = 7 - 2^2 = 3$.

The other three roots or values of x, are those of (2). By Sturm's Theorem, the roots of (2) are found to be *real*, but incommensurable with unity, and one of them lies between 3 and 4, a second root between -3 and -4, and the third between -1 and -2. By Horner's Method these roots are found to be approximately, $x = 3.1313125$, $x = -3.283186$, and $x = -1.84812652$. The corresponding values of y, from $y = 7 - x^2$, are $y = -2.8051181$, $y = -3.779310$, and $y = 3.58442837$. These, with the corresponding values of x, will satisfy the equation $x + y^2 = 11$ to at least six places of decimals. The writer at one time computed and verified the values of x and y, for a friend, to thirteen decimal places by the method here stated.

The associated values of x and y are:

$$\left.\begin{matrix}x=2\\y=3\end{matrix}\right\} \quad \left.\begin{matrix}x=3.1313125\\y=-2.8051181\end{matrix}\right\} \quad \left.\begin{matrix}x=-3.283186\\y=-3.779310\end{matrix}\right\} \quad \begin{matrix}x=-1.84813652\\y=3.58442837\end{matrix}$$

The last three sets of values are, of course, only approximate. GEORGE W. COAKLEY.

Hampstead, Long Island, N. Y.

EDITORIAL NOTES.

Volume VIII of the MESSENGER closes with this number. Patrons will please bear in mind that all subscriptions for the year 1889 also end with this issue. Those that wish the journal continued, who have not already done so, will confer a favor by notifying the publisher at once, that mailing lists for January may be correct.

It is very gratifying to receive so many words of commendation, during the last month, in regard to new features for this periodical for the year 1890. We wish to assure these many friends that their well chosen words give more encouragement and heart in this difficult, though useful work that we have undertaken, than they can realize unless they have had a like experience. The change of subscription price to $3 was the most trying part of it all for ourselves, but the need of it, for the better results in the future plan seemed clearly necessary and therefore the change was made after careful consideration.

Now, as a new start is to be taken, contributors are respectfully asked and kindly urged to make communications as brief *as possible*, consistent with a clear setting forth of the matter to be presented; and if manuscripts are plainly written and simply worded, the points made will certainly be more attractive and forceful for the general reader.

Drawings of the Milky Way. In November *Knowledge* attention is called to three large detailed drawings of Milky Way made, by Dr. Otto Boeddicker, assistant to the Earl of Rosse at Parsonstown. The space covered by these maps is a little more than the northern half of the Galaxy extending from 10° south of the celestial equator. One map gives the whole view, the other two show the same on a larger scale. Dr. Boeddicker was occupied five years in completing this work, and, in detail, the drawings are said to vary considerably from the work of Heis and Gould. It is suggested that the Galaxy offers an inviting field for those observers who are provided with photographic telescopes, for its detailed structure may be the key that we need, to lead to a better understanding of sidereal astronomy.

The Yarnall Catalogue of Stars Revised and Corrected. A copy of the Yarnall catalogue of stars, as revised and corrected by Professor Edgar Frisby, of the United States Naval Observatory has been received. The first edition of this catalogue was published in 1873 by Mr. Yarnall, and was in the same form as it now appears. In 1878 a second edition was published by Mr. Yarnall, which gave better places of some of the stars previously observed but once or twice. The object in publishing a third edition of this catlogue at the outset was to correct the errors generally known to exist in the previous ones. Professor Frisby had not gone far in this work before he learned that he had a greater task on hand than had been anticipated; for it seemed necessary that a more complete and systematic examination should be made than had been done before, including a re-examination of all anonymous stars, comparing the named stars with those of existing catalogues, re-numbering of all the stars, changing names wherever necessary, and supplying names that existed previous to the publication of the catalogue. In this he was greatly aided by the recent publication of the Southern Durchmusterung, Gould's Zones, and General Catalogue, in identifying many stars, and in correcting the records of others. One common mistake in the former editions was due to combining the right ascension of one star with the declination of another, a very easy mistake whenever the right ascension is observed by one instrument and the declination by another. The other sources of error are mainly such as notice here would not help any one to avoid like errors in similar work.

In giving names to stars the following principles have generally been adopted, taking care, however, not to change the existing names unless for some good and satisfactory reason:

1. The oldest name in any standard catalogue has been preferred unless there was some uncertainty or mistake in that catalogue, or unless the name already used was that of one of the recognized standard authorities, although not the oldest. 2. No catalogue issued since the publication of Yarnall's Catalogue has been used for that purpose. Most of the names in the British Association have been retained, although, in the case of double stars, or such stars that had

one authority given in that catalogue the original name has been retained.

Following this catalogue of 10,964 stars are 25 pages of notes referring to the mistakes in the second edition and the changes that have been made in the third. We give one illustration from these pages which is a fair example: "New numbers 593, 622; old number, 590, Right Ascension and Declination belong to different stars, the given Right Ascension also being 1*m* wrong for the former star." For those who have not seen the former editions of this catalogue it may be said that the arrangement is, first column, Catalogue number of star; 2d, star's name; 3d, magnitude; 4th, 5th, 6th and 7th (between heavy vertical lines), respectively, mean right ascension for 1860, mean year, number of observations, annual precession for 1860. The last four columns on the page are respectively, mean declination for 1860, mean year, number of observations, annual precession 1860.

Apparently this revision is a thorough piece of work, and one that has been much needed.

Washington Transit-Circle Observations of the Sun 1875-1883. The September number of the *Monthly Notices* contains a discussion of the observations of the Sun, made with the Washington Transit-Circle, during the years 1875-1883 inclusive, by A. M. W. Downing. This investigation was undertaken because of the comparatively large discordances in the position of the equinox, as found from the meridian observations of the principal Observatories. The observations of the sun so made ought, from time to time, to be discussed and a determination of the position of the equinox found, which will be supported by the weight of all. This is what Mr. Downing has tried to do with apparently great care, using 103 equations of condition in the final reduction.

The corrections to the principal systems of right ascensions resulting from this discussion of Washington observations of the sun are as follows:

Washington (1875-1883)	— American Ephemeris (Newcomb)	= — 0.016
	— Berliner Jahrbuch (Auwers)	= — 0.000
	— Greenwich (1880)	= + 0.026
	— Pulkowa (1845)	= + 0.003
	— Pulkowa (1865)	= + 0.052
	— Conn. des Temps. (1883)	= + 0.029

An improved Astronomical Mirror is the title of an illustrated article that appeared in the *Scientific American* (Sept. 7). The claim there made is that concave mirrors of long focus may be readily produced from plane-faced mirrors and that the process has been patented by Dennis O'Brien of Oswayo, Penna. This process is so novel, and the probability so great that it will be an astonishing improvement on the old form of parabolic mirror that we copy a single paragraph, as follows:

"The mirrors to be formed must be of a parabolic section, a true parabolic mirror 6 feet in diameter and 72 feet focus having a central depression of just 3/8 of an inch. To make such a mirror a pan is employed, preferably made of cast metal to be extremely rigid, and with flanged edges by which it may be bolted by three equidistant bolts to the flanged end of the tube. This pan is formed with a seat or shoulder, upon which there is placed a plane mirror, through the axis of which there is drilled a small hole adapted to receive a tube, with threaded ends to engage an upper and lower disk fitting on the upper and lower faces of the mirror. The bottom of the pan has a central aperture through which is passed a headed and threaded tube engaging the other tube; and the tube passing through the bottom is turned by means of a suitable wrench, to draw the center of the mirror down against its own rigidity, bending it into concave shape. It is estimated that the central disk need not be larger than half an inch in diameter for a six-foot mirror, and this bending of the mirror is preferably done while the mirror is set facing a test object."

Is there one chance in a million that such a mirror as that would be good for anything for astronomical purposes?

Law of Density of Planetary Bodies. Robert Hooke has published an article in *The American Journal of Science* (November) titled "Law of Density of Planetary Bodies." The hypothesis adopted is, "that the material which forms the principal part of the masses of the planets and their satellites would, when subjected to the same conditions of temperature and pressure, have the same density." By this hypothesis it follows, that all planetary bodies would have the same surface density as rapidly as they reach the same physical condition.

In seeking the relation of density to diameter in planetary bodies, it is obvious that the so-called older planets, Mercury, Venus, Mars, Earth and the satellites generally, which have reached a solid condition, are the only ones from which the physicist can determine a relation between the surface density and the mean density. This is Mr. Hooke's first step. But, in seeking this relation, he does not want the mean density of the planet as a whole, but only that part of it which is due to compression, if he is rightly to find the law of density to diameter. This value, Mr. Hooke claims, is the *difference* between the surface density and mean density as a whole.

This point in the discussion is an interesting one, and is claiming the attention of physicists at the present time.

From values of the surface and mean densities and diameters of the earth and moon, the following conclusion is reached, viz: *the increase of the difference between the mean and surface density is proportional to the increase of diameter.*

If equations are formed and applied to Mars, Venus and Mercury, we have the following numbers:

Mars	4211	4.22	4.17	$\frac{1}{3093500}$
Venus	7660	5.56	5.24 (?)	$\frac{1}{390000}$
Mercury	2992	3.74	4.56 (?)	$\frac{1}{7500000}$

The first column represents the diameters, the second the value computed from the law of density, the third, value computed from assigned values of masses and diameters, and last Mars, (sun = 1). The agreement of values in the case of Venus and Mercury is so bad that confidence is weakened in the principle as a general one. Further study, however, may remove this difficulty.

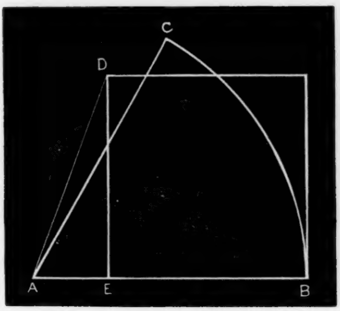
An interesting application of this relation of density, has been made by Mr. Hooke to determine, by computation, the diameters and densities of the sun and the outer planets when they shall have become solid like the earth and moon. The results are as follows:

	Diameters	Mean Diameters.
Sun	218,808 miles	87.69
Jupiter	37,183	17.04
Saturn	27,128	13.13
Uranus	16,552	9.00
Neptune	17,220	9.28

Several other points of equal interest are found in this suggestive article.

Mr. A. S. Flint of the U. S. Naval Observatory, Washington, D. C., has been appointed assistant at the Washburn Observatory, Madison, Wis.

Relative Distances of the Inner Planets from the Sun. Bode's law enables us to state roughly the relative distances of the major planets from the sun. The following device, concerning the inner group only, has the advantage of giving very close approximations, at the same time representing the results to the eye by means of geometrical figures.



Draw a sextant and a square equal to it in area; arrange them as in the figure, and draw AD.

Let the radius AB represent the earth's distance; then EB represents that of Venus; the perimeter of the sextant ABCA twice that of Mars; and AD twice that of Mercury.

The distances as thus determined are given in the first column and the true distances in the second :

Mercury, - - - - -	.3873	.3871
Venus, - - - - - -	.7236	.7233
Earth, - - - - -	1.0000	1.0000
Mars, - - - - -	1.5236	1.5237

A Bibliography of Geodesy. We have received a full and very important paper entitled "A Bibliography of Geodesy," prepared by J. Howard Gore, B. S., Ph. D., Professor of Mathematics, Columbian University, Washington, D. C. This paper was published as Appendix No. 16 to the Report of 1887, by the United States Coast and Geodetic Survey, F. H. Thorn being superintendent. A casual glance at this book of 300 closely printed and double-column pages, of large size, will give little idea of the immense labor involved

in it. One only begins to realize something of the task when he knows that Professor Gore, in the outset visited in person thirty-four of the principal libraries of America and Europe, consulted many minor libraries by proxy, and undertook, in addition a searching inquiry by correspondence with all the geodesists or mathematicians of both continents. That interest was awakened in his work, abroad, is apparent, for Col. Herschel very courteously gave Professor Gore access to his manuscript contribution to Pendulum Bibliography, and the International Geodetic Association at Berlin offered to undertake the publication of his book. This was certainly a gratifying evidence of Professor Gore's fitness for the work as well as an indication of its anticipated value which an examination of the paper now fully sustains.

In the plan of this work one alphabet only is used for authors, abbreviations and subjects and that a neat heavy faced letter. The full names of authors are witten whenever possible at first, but when repeated, the last name with initials of the Christian name appears. The works of authors are arranged chronologically under their names and in many instances helpful notes are given which show leading subjects treated by the writer. This is a time saving arrangement in the canvass of authors on special themes. Scholars will regard this piece of work as one of the most important of its kind that has ever been published.

Longitude of Carleton College Observatory. During the last month Carleton College Observatory exchanged telegraphic time-signals with the Naval Observatory at Washington, D. C., for three nights, for the purpose of determining the longitude of the former Observatory more closely. Professor A. N. Skinner observed at Washington, and Dr. H. C. Wilson at Northfield. The reductions have not yet been completed. The telegraph line between Northfield and Washington had but one repeater for the whole distance, and service was excellent. This will be spoken of more fully later.

Errata. On page 424, occultation of Jupiter, column headed J. E. K., omit the note to the time of first contact of Jupiter; the time does not require any correction. In the same column the + signs should be ± indicating an approximate observation. The copy from which this matter was set was uncorrected page proof, hence the errors.

BOOK NOTICES.

Unto the Uttermost. By James M. Campbell. Messrs. Fords, Howard & Hulbert, publishers. New York, 1889. 234 pp. Vellum cloth; price, $1.25.

The author of this book is a preacher of the Congregational faith, one of that increasing class of earnest enquirers who are not afraid to say, "I do not know," while yet they demand a hearing for their well considered reasons for saying, "I believe;" but their faith is in God rather than in the wisdom of men. The line of his discussion in this thoughtful book is well suggested in the titles of its chapters which are as follows:

Unto the Uttermost; Castaway Reclaimed; Grace Conquering Nature; A Pessimistic View; The Limits of Evolution; Modern Miracles; The Higher Environment; The Universality of Divine Providence; Redemptive Effort a Necessity of the Divine Nature; The Sin that Shuts the Door of Mercy; The Chief Danger Point; Fluidity of Character; Judicial Blindness; A Common Spiritual Disease; Past Feeling; Bartering the Birthright; Death a Loss; The Finality of the Present.

We must confess that as we perused the earlier chapters we were a little afraid that the author was preparing to land us in the hazy regions of the Andover unpleasantness, willing or unwilling, possibly; for he certainly writes with point and tact on hard themes, and we relished unusually the fresh putting of the chosen trains of thought belonging to each topic.

But when we finished "The Sin that Shuts the Door of Mercy," "The Chief Danger Point," and "The Finality o the Present," we were ready to say, in the judgment of a layman, Mr. Campbell is 'sound'; he is orthodox after the good old western style of belief, although he tells it in a little different way than do some of his good brother ministers. It is evident that he does not believe in limiting God's mercy, but that he is concerned about, and calls very frequent attention to, limitations on man's capability and willingness to grasp, at possible cost, the essentials of life and faith as taught by Jesus Christ. The probationists will find much worth thinking about in the compact and weighty sentences of these chapters, and religious readers and thinkers will peruse the entire book, we think, with a feeling of conscious and added strength, where prevailing opinion is in need of

more careful statement for its ready support against the attacks of recent dogmas that some reputed scholars are urging with unmistakable influence, and, as we believe, with harmful effect.

Elementary Mathematical Tables. By Alexander MacFarlane, D. Sc., LL. D., Professor of Physics in the University of Texas. Messrs. Ginn & Co., publishers, Boston, U. S. A., and London; 1887, pp. 105.

The purpose of this new book of tables is not only for ordinary computation and the uses in graphic methods in general, but also in the teaching of arithmetic, and in the illustrations of the theories of algebra. The table of common logarithms are four-place and first pages are for any sequence of three significant figures, with difference column on the right hand side of the page, and a small table at the bottom of the page for proportional parts of small numbers.

Later pages give the logarithms of any sequence of four places from 1,000 to 1,900, and a small table giving the logarithm of six places of numbers 1.000 to 1.100 which occur in the calculation of interest. Then follow in order tables respectively with these titles: Antilogarithms; Addition Logarithms; Subtraction Logarithms; Logarithmic Sines and Cosines; Logarithmic Tangents and Cotangents; Natural Sines; Cosines, Tangents and Cotangents; Secants and Cosecants and Radius Equivalent in Degrees. Tables also of reciprocals, squares, cubes, square roots, cube roots; multiples of 100—999; circumference of circles; area of circle; constant of sphere; hyperbolic logarithms; amount at the end of *n* years, present value of 1,000; amount of an annuity paid at the end of each year; present value of the same; amount of an annuity paid at the beginning of each year; sum to be paid at the end of each of *n* years to extinguish a debt of 1,000; least division; exponentials; and multiples from 1 to 100.

The reader will wonder at this extended list of tables to be found in one book containing only 105 pages, but he is assured they are all there in clear figures of heavy and light face type, sufficiently open and large for easy reading. The tables do not extend as far as those of the larger volumes with more places, and the plan on which they are made varies somewhat. A hint or two on the table of logarithmic sines and cosines will help the reader to form some idea of

the construction. Pages fourteen and fifteen contain the sines and cosines of the *degrees* only from 1 to 89 in first and last vertical columns. Between these are 11 columns of four place functions headed at the top respectively .0, .1, .2, etc., to 1.0 of degrees. The reductions to minutes of arc would be done mentally when desired. From this arrangement the interpolation for odd minutes is of course very easy. It seems to us that this book of tables is a very handy and useful one for the table of the teacher or the general computer. We are not able to speak of its accuracy for the want of time to make the necessary comparisons for personal knowledge, but the names interested in its publication in England and at home, are doubtless a strong guaranty for this. It is rather a novel feature that a book of this kind should be published simultaneously in the two countries.

Celestial Motions is the title of a small, handy book of Astronomy by William T. Lynn, F. R. A. S., recently revised and enlarged. The first edition appeared in 1884, the latest revision belongs to the present year. This little work is meant only to be a concise digest of the most important facts pertaining to the motions of the celestial bodies, especially those of the solar system. Care has been exercised to give the latest reliable information which could be secured in plain language and without the use of technical terms to hinder the popular reader.

The author makes no attempt at fine essay writing, but presents the following topics, in such a way, as to convey the facts about them that an interested reader would like to know, viz., the earth, moon, sun, solar system, planets, comets, meteors, fixed stars, constellations, refraction, propagation, observation of light and a sketch of the history of astronomical discovery, a table of astronomical terms explained and index to subjects and names.

The best thing that can be said, further, about this little book is that a young man took it from our table, the other day, and became so interested in it that he did not stop until the greater part of it was read.

The book contains 144 pages and is published by Edward Stanford, 26 and 27 Cockspur street, Charing Cross, S. W. London, England, 1889. Price half a crown.

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